



Fermi National Accelerator Laboratory

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Loma Linda - Coherent Instability Survey

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LOMA LINDA – COHERENT INSTABILITY SURVEY

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ABSTRACT

This note outlines briefly coherent instability limits of the Loma Linda Medical Accelerator. The study of effective impedance constructed for particular longitudinal and transverse beam spectra allows us to select a set of potentially offending instabilities. Due to increasing kinematic "stiffness" of the beam at higher energies, here, we consider thresholds of the above instabilities at injection only. A numerical study of the intensity thresholds (or the characteristic growth-times) concludes this study.

Longitudinal Stability

♦ The *microwave instability*, which provides the lowest threshold, will dominate the low energy region corresponding to the injection at 70 MeV ($\gamma = 1.004$). Although the transverse beam size is quite large (95% beam radius of 2×10^{-2} m) the lowest energy is dominated by the space charge effects (capacitive longitudinal coupling impedance of $|Z/n|_{s-c} = 4 \times 10^3$ Ohm). The broad-band contribution to the longitudinal impedance (induced by the bellows) is equal to $|Z/n|_{b-b} = 7 \times 10^2$ Ohm (TBCI simulation). Assuming beam intensity of 5×10^{10} ppb and the net value of $|Z/n|$ (including both the broad-band and the space-charge parts) yields the threshold value of the longitudinal momentum spread $\Delta p/p = 2.9 \times 10^{-3}$, while the allowed value of $\Delta p/p$ with the space charge forces only is 2.7×10^{-3} . Both thresholds are summarized in the table below. Some reduction of the longitudinal impedance e.g. a compensation by an induction part generated by a helical transmission line may be considered.

E_k [MeV]	$ Z/n _{s-c}$ [Ohm]	$ Z/n _{b-b}$ [Ohm]	$\Delta p/p$
70	4×10^3	7×10^2	2.9×10^{-3}
70	4×10^3	0	2.7×10^{-3}

Transverse Stability

♦ The *resistive wall instability* driven by the wake fields due to the Lambertson magnet lamination and resistive vacuum chamber walls dominates the coherent betatron motion in the low frequency region. Assuming the beam intensity of 5×10^{10} ppb the characteristic growth-time of the instability is $\tau = 5 \times 10^{-2}$ sec. For lower energies the incoherent space-charge force produces enough betatron tune spread (Laslett effect) to suppress the instability through Landau damping. Above the cross over energy of 180 MeV some decohering mechanism is required e.g. an amplitude dependent betatron tune induced by small octupole field component.

♦ The transverse impedance in 200 MHz region is mainly due to the electrostatic kicker. Its value is too small to support any single bunch instability e.g. *slow head-tail instability*. A simple estimate of the characteristic instability growth-time for various modes (Sacherer's model) yields the growth-times of $\tau \sim 10^{-1}$ sec., therefore this instability is negligible.